International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 7 Issue 3, May-June 2023 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Wireless Power Transmission System- A Review

Mrs. Yogita Shailesh Kadam

Lecturer, Department of Electrical Power System,
Vidya Prasarak Mandal's Polytechnic, Thane, Maharashtra, India

ABSTRACT

The wireless Power Transmission is a useful and proper technology is used in various fields like electronic devices, implantable medical devices, industry and other fields, and has become a research hotspot at home and abroad. Because it enables the transmission of electrical energy from a power source to an electrical load across an air gap without interconnecting wires. This paper reviews the methods used in the wireless power transmission system, recent technologies, future and its application, merits as well as demerits.

KEYWORDS: *WPT, Electromagnetic Radiation, Induction Coupling, MCR, MPT, LPT, Qi, A4WP, PMA*

How to cite this paper: Mrs. Yogita Shailesh Kadam "Wireless Power Transmission System- A Review" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-7 | Issue-3, June 2023, pp.427-431, URL: www.ijtsrd.com/papers/ijtsrd57380.pdf

IJTSRD57380

I. INTRODUCTION

Wireless power transmission is the transfer of energy over a long distance without the use of separate artificial conductors. A conventional way of transmitting electricity from one point to other is through cable. But the major issue in this transmission is power loss due to the conductor and other equipment used for electricity transmission. If the quality material is used to reduce power loss then there is significant rise in cost. As the demand of power consumption increases day by day, the power generation and then the power loss is also increased. This also results into increase in cost which is harmful to the environment due to the production of electricity. The saved power can be used as an alternative to minimize the cost. Hence in order to reduce power loss or save power, wireless power transmission has been used. In situations where linking cables are difficult, harmful, or impossible, wireless transmission is advantageous.

It is used in biomedical applications, Electric Vehicle charging, charging of electronic devices etc. The general form of wireless power transmission is direct induction and then resonant magnetic induction. Other technologies under investigation are radio waves, such as microwaves, or laser beam technology, depending on the distance over which the energy must be carried.

This paper will briefly survey the different wireless power transfer technologies and compare them in different features. The structure of this paper is as follows:

Section I: Introduction
Section II: Review on Wireless Power Transfer.
Section III: The recent technologies in wireless power transmission
Section IV: Some applications of power transmission
Section V: Merits and Demerits
Section VI: Conclusion

II. WIRELESS POWER TRANSFER (WPT)

Another name of Wireless power transmission is inductive power transfer. This technology provides efficient, fast, low maintenance cost and less loss as compared to previous technologies. It can be used for short range or even long range without cable. It allows electrical devices to be charged continuously and lose restriction of power cable. Microwave,

Resonance and Solar cells, these are the three systems used for WPT.

Nikola Tesla was the first to led the experiment on Wireless Transmission of electrical power in late Nineteenth Century. He did experiment on Transmission using a tesla coil radio frequency resonant transformer, which created a high voltage of high frequency alternating currents. It allows transfer of power over short distances without the use of wires. He used a resonant circuit which is earthed on one end to successfully light a small incandescent lamp.

Today, portable technology is a part of everyday life. Almost all portable devices are battery powered; means recharged using the wired chargers. Now instead of plugging in a cell phone, PDA, digital camera, voice recorder, mp3 player or laptop to recharge it, it could receive its power wirelessly [3]. Although wireless power transfer is feasible and helps in human daily lives, but this technology suffers from several drawbacks namely requires a network of hundreds of satellites and interference with other electronic devices. WPT can be categorized into two techniques: Far-field and Near field WPT system. In general, lower frequency transmission provided by far-field techniques with simple pattern measurements and higher frequency transmission with near-field technique and complete pattern measurements [4] [6] [16].

A. Near-Field Techniques

The technique which measures with appliance near from the power source is known as Near-Field Techniques. It can be divided into three categories. They are electromagnetic radiation, inductive coupling, and magnetic resonant coupling. The problem due to weather and security concerns can be vanished by these techniques.

1. **Electromagnetic (EM) Radiation**: Energy transmission from transmitting antenna to receiving antenna through electromagnetic waves is called as Electromagnetic radiation. Radio waves with a frequency band are used for wireless transmission. The information is superimposed on the electromagnetic carrier wave as amplitude modulation (AM) or as frequency modulation (FM) or in digital form (pulse modulation). According to the direction of emitting energy, there are two section classified as omnidirectional radiation and unidirectional radiation. Through omnidirectional radiation process, broadcasting is done in an assigned ISM band for example 850–950 MHz or 902–928 MHz in the U.S. which can be varies with the different region both with 915 MHz center frequency, and a receiver for example RFID tags tunes to the same frequency band to harvest radio power [1]. Information transfer is more easy and suitable in omnidirectional radiation but as the distance increases it suffers efficiency problem due to quick decay of EM waves. By the experiment it was found that when a receiver is 30 cm away from the RF transmitter, power transfer efficiency is only 1.5% [1]. In addition, to protect potential health hazards of humans from EM radiation, only appropriate process is omnidirectional radiation for ultra-low-power sensor nodes for example up to 10 mW with very low sensing activities like temperature, moisture and light. If there is a clear line-of-sight (LOS) path exists in the process of unidirectional radiation, it can gain high power transmission over a much longer distance for example by using a microwave or laser beam the range can be in kilometer. In the microwave-based system mostly, wireless power is transmitted on microwave frequencies of either 2.45 or 5.8 GHz, both in the ISM frequency band. In the Laser-based system, it is still considered less mature than microwave-based system, transmit power under the visible or near infrared frequency spectrum as an example from several THz to several hundred THz [1].
2. **Inductive Coupling**: It is a coupling between two LC circuits where resonant frequency is same. It works by using magnetic field induction. For example alternating current in a primary coil can produce a varying magnetic field that induces a voltage across the terminals of a secondary coil at the receiver. Primary and secondary coils are in electrical isolation. Due to its simplicity, convenience, and safety, inductive coupling has been an important and popular technology to transfer power without wires. This technology is successfully commercialized to a number of products, including electric toothbrush, charging pad for cell phone or laptop, and medical implants. If the two coils are being separate slowly from each other or their alignment is not perfect then power transfer gradually decreases. It works best when the charging node of the device and power receiving node are close in contact usually less than a coil diameter, for example the range can be in centimeter and the direction of the charging must have to be aligned. [1]

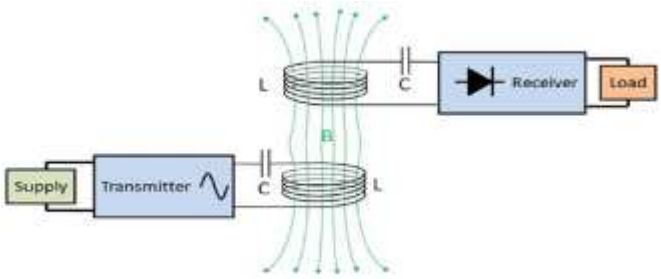

Figure 1 Wireless Power Transfer through Inductive Coupling

3. **Magnetic Resonant Coupling (MRC):** This technology was developed by Kurs et al., due to the combination of inductive coupling and resonance it makes the interactions between two different objects very strong [1]. The effect of magnetic resonance is analogous to the classical mechanical resonance. In mechanical resonance, when a string tuned to a certain tone it can be excited to vibration by a faraway sound generator if there is a match between their resonance frequencies. In this technology, the transmitter and receiver inductors are tuned to a same resonance frequency hence energy is transferred efficiently from a source coil to a receiver coil with little loss of energy. An electrical transformer is a good extraneous off-resonant object. There are several advantages of this technology like highly efficient, less radiation loss, provides much greater range and directional as compared to inductive coupling [1] [5] [7]. A common use of the technology is for powering contactless smartcards, and systems exist to power and recharge laptops and cell phones.

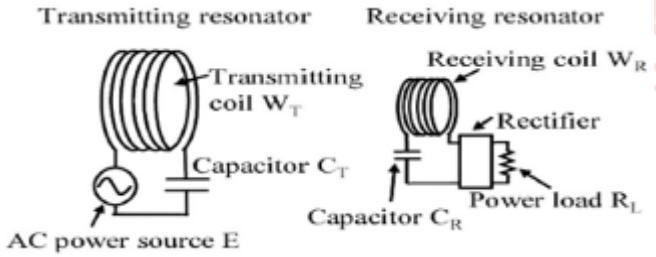

Figure 2 Wireless Power Transfer through Resonant Coupling

B. Far-field Techniques: These techniques are measuring the electrical load far from the power source, aim at high power transfer and need line of sight. It can be divided into two categories, microwave power transmission and laser power transmission [8].

1. **Microwave Power Transmission (MPT):** When two places being in line of sight then high power from the base station to the receiving station or mobile devices can be transferred using this technology. When the MPT technology organised with geosynchronous receiving and transmitting satellites, the objects gained power from the base station by utilizing the magnetron. Though MPT provides the efficiency in energy conversion, it is slightly difficult to focus the beam over a small area. The power transmission is started with the conversion of electrical energy to the microwave energy and then microwave energy is captured with the help of rectenna. In this technology, AC cannot be directly converted to microwave energy. Therefore, it is necessary to do first, AC to DC conversion and then by using magnetron DC is converted to microwaves and these waves are received at rectenna and then efficiently changes the microwaves to electricity, It will be in the form of DC. At the end, DC will be converted back to AC [9] [10-13].

2. **Laser Power Transmission**: This technology is slightly different with MPT where it enables the power concentrated in a small area by utilizing the mirror. It (LPT) transmits power under visible or near-infrared frequency. This technology also produces high powers that are articulate and not spread. However, laser technology gets reduced when it broadcasts through atmosphere. In addition, this technology has been used to apply to a rover to explore the presence of ice in the bottom of craters of the moon where no sunlight is available. On the other hand, the solar energy generated by the radiation is converted into the electric energy. This energy next will be converted to the laser light and then transmitted to the rover working at the bottom of the crater [2] [14].

III. RECENT TECHNOLOGIES

A. Qi Technology: Qi technology supports a charging distance of a few centimeters and uses the small inductors to transmit power over higher frequencies. Qi components use multiple resonator arrays to create a larger charging area due to its limitation on charging area. But to switch on individual coil a lot of power is wasted. However, it still does not lessen the problem and therefore, to keep a strong enough connection, users need to align their devices precisely with the magnetic fields [15] [17]. Currently, the wireless charger can get warm during charging and it will heat up the near part of a device due to its conductive material. To control the power consumed by the multiple coils, a limited communication protocol add-in by the Qi. Along with this the receiving device can tell the charger how much power it requires and when it is fully charged. Additionally, the charger can modify its power output to suit any receiving devices and can switch to standby mode once the device is

fully charged or if no device is attached. Companies that utilize this standard for charging their devices are Samsung, LG, Philips, Toyota, Microsoft, and Sony [18].Limitations of Qi are single device charging, metal heating, positional alignment necessity, etc. [19].

B. Alliance for Wireless Power (A4WP): This technology is based on reference power transmitting and receiving resonators without the use of interconnecting wires, enables the efficient transfer of power to electronic devices. [21]. It allows multiple devices to be charged with differing power requirements from a single transmitter at any one time. Due to the use of larger electromagnetic field instead of the small inductor coils, no need of line-up the devices to be charged precisely with the coil. Although A4WP has not released to the market yet the existence of this technology enables the electronic devices to be charged in any positions including Z-axis and do allows charger to be implanted in the objects where the magnetic fields can still emit the energy from the objects [20] [22].

C. PMA Technology: Another most recent technology is Power Matters Alliance (PMA). This is the organization with the aim of forward thinking in a global, not-for-profit, industry where better power paradigm for battery equipped devices using wireless charging technology has been working with a bunch of research group leaders. PMA has grown rapidly since being founded in 2012. Recently more than 100 members across a diverse set of industries including telecommunication, consumer devices, automotive, retail, furniture, surfaces and more are working with this new standard of technology. PMA growth and success is attributed to a unique approach of making wireless charging ubiquitous in the places that consumers need it most as well as the hard work and dedication for members [23].

IV. APPLICATIONS

- Moving targets such as fuel free airplanes, fuel free electric vehicles, moving robots and fuel free rackets.
- WPT are used for Ubiquitous power source, RF power Adaptive Rectifying Circuits (PARC)
- Wireless charging of wearable electronic such as watches, air pods, and mobile phones.
- Wireless sensors which receive electric current from the rectenna (rectifier + antenna) attached to it.
- Low power applications (μW – several watts) like RFID, satellite communication.
- Telemetry which is an automatic recording and transmission of data from remote or inaccessible sources to an IT system in a different location for monitoring and analysis.
- Implanted medical devices including LVAD heart assist pumps, pacemakers, and infusion pumps. and Automotive industries.
- Stationary charging (Plug-in) EV's and Dynamic charging EV's.
- Power generation using satellites fitted with large solar panels and transmitting that power in the form of microwaves also called a "solar satellite ". is the most demanding application which is under development.
- Automatic wireless charging for mobile robots, cordless tools and instrument which eliminates complex mechanisms, and labour intensive manual recharging and battery replacement.

V. MERITS AND DEMERITS

VI. Merits

- No need of a power cord or battery replacement
- The power failure due to short circuit and fault on cables would never exist in transmission.
- Reduction of E-waste by eliminating the need of power cords.
- Wireless charging offers no corrosion as the electronics are all enclosed, away from water or oxygen in the atmosphere.

VII. Demerits

- The capital cost for particle implementation of WPT seems very high.
- WPT may cause interference with present communication systems.
- Less efficiency compared to traditional charging.

VIII. CONCLUSION

It offers greater possibilities for transmitting power with negligible losses. As wireless technology is getting popular now a days, the demand of battery is also decreasing. For the long range power transmission power can be sent from source to receivers instantaneously without wires, reducing the cost. If recent three technologies are compared then A4WP standard must be keep ahead which has the huge magnetic field and large charging distance then other standards whereas Qi and PMA also improving very fast. If wireless power keeps improving then more applications that are in under research will be in our daily uses with wireless power charging.

IX. References

[1] Liguang Xie; Yi Shi; Hou, Y.T.; Lou, A., "Wireless power transfer and applications to sensor networks," Wireless Communications, IEEE , vol.20, no.4, pp.140,145, August 2013.

[2] Pawade, Sourabh, Tushar Nimje, and Dipti Diwase. "goodbye wires: approach to wireless power Transmission." Int. journal of emerging technology and advanced engineering. ISSN: 2250-2459.

[3] Schneider, D., "Wireless power at a distance is still far away [Electrons Unplugged]," Spectrum, IEEE , vol.47, no.5, pp.34,39, May 2010.

[4] Gozalvez, J., "WiTricity-The Wireless Power Transfer [Mobile Radio]," Vehicular Technology Magazine, IEEE , vol.2, no.2, pp.38,44, June 2007

[5] Teck Chuan Beh; Kato, M.; Imura, T.; Sehoon Oh; Hori, Y., "Automated Impedance Matching System for Robust Wireless Power Transfer via Magnetic Resonance Coupling," Industrial Electronics, IEEE Transactions on , vol.60, no.9, pp.3689,3698, Sept. 2013.

[6] Kurs, Andre; Moffatt, Robert; Soljacic, Marin, "Simultaneous midrange power transfer to multiple devices," Applied Physics Letters , vol.96, no.4, pp.044102,044102-3, Jan 2010 .

[7] Kurs, Andre, et al. "Wireless power transfer via strongly coupled magnetic resonances." science 317.5834 (2007): 83-8

[8] Radiom, S., Baghaei-Nejad, M., Aghdam, K., Vandenbosch, G. A., Zheng, L. R., and Gielen, G. G. (2010). Far-Field On-Chip Antennas Monolithically Integrated in a Wireless-Powered 5.8-GHz Downlink/UWB Uplink RFID Tag in 0.18-Standard CMOS. SolidState Circuits, IEEE Journal of, 45(9), 1746-1758.

[9] Shouyin, Z. (2000, September). Development of quasi-optical microwave transmission lines in microwave diagnostics systems on Hefei tokamaks. InInfrared and Millimeter Waves, 2000. Conference Digest. 2000 25th International Conference on (pp. 89-90). IEEE.

[10] Ying Fu; Wang, T.; Johan Liu, "Microwave-transmission, heat and temperature properties of electrically conductive adhesive," Components and Packaging Technologies, IEEE Transactions on , vol.26, no.1, pp.193,198, March 2003

[11] Whitehurst, L. N., Lee, M. C., and Pradipta, R. (2013). Solar-Powered Microwave Transmission for Remote Sensing and Communications. IEEE Transactions on Plasma Science, 41(3), 606- 612.

[12] Gutierrez-Martinez, C.; Santos-Aguilar, J.; Torres-Fortiz, J.A.; Morales-Diaz, A., "Using photonic filters for tuning dispersion-indused microwave transmission windows on radio over fiber schemes," Microwave and Optoelectronics Conference, 2007. IMOC 2007. SBMO/IEEE MTT-S International , vol., no., pp.450,453, Oct. 29 2007-Nov. 1 2007

[13] Huang, H., and Castillo, E. (2012, May). Wireless interrogation of microwave transmission line for distributed sensing. In Millimeter Waves (GSMM), 2012 5th Global Symposium on (pp. 135-138). IEEE.

[14] Feng, G., Wang, Q., Yang, P., Zhang, J., Wang, Z., and Liu, F. (2011, July). Diagnostic technology for temporal-spatial distribution of farfield high power laser beam profile. In Electronics and Optoelectronics (ICEOE), 2011 International Conference on (Vol. 2, pp. V2-30). IEEE.

[15] Waffenschmidt, E., "Wireless power for mobile devices," Telecommunications Energy Conference (INTELEC), 2011 IEEE 33rd International , vol., no., pp.1,9, 9-13 Oct. 2011.

[16] Massa, A., Oliveri, G., Viani, F., and Rocca, P. (2013). Array Designs for Long-Distance Wireless Power Transmission: State-of-the-Art and Innovative Solutions.

[17] Qi wireless power consortium www.wirelesspowerconsortium.com

[18] Mou, S. Member, and H. Sun, "Wireless Power Transfer : Survey and Roadmap", IEEE Vehicular Technology Conference, no. 646470, pp. 1–13, 2015

[19] P. Dubal, "Rezence – Wireless Charging Standard based on Magnetic Resonance," Int. J. Adv. Res. Comput. Commun. Eng., vol. 4, no. 12, pp. 198–200, 2015.

[20] Alliance for wireless power www.rezence.com

[21] Caldara, M.; Colleoni, C.; Galizzi, M.; Guido, E.; Re, V.; Rosace, G.; Vitali, A., "Low power textile-based wearable sensor platform for pH and temperature monitoring with wireless battery recharge," Sensors, 2012 IEEE, vol., no., pp.1,4, 28-31 Oct. 2012.

[22] Tseng, R.; von Novak, B.; Shevde, S.; Grajski, K.A., "Introduction to the alliance for wireless power loosely-coupled wireless power transfer system specification version 1.0," Wireless Power Transfer (WPT), 2013 IEEE, vol., no., pp.79,83, 15-16 May 2013.

[23] Power matter alliance www.powermatters.org